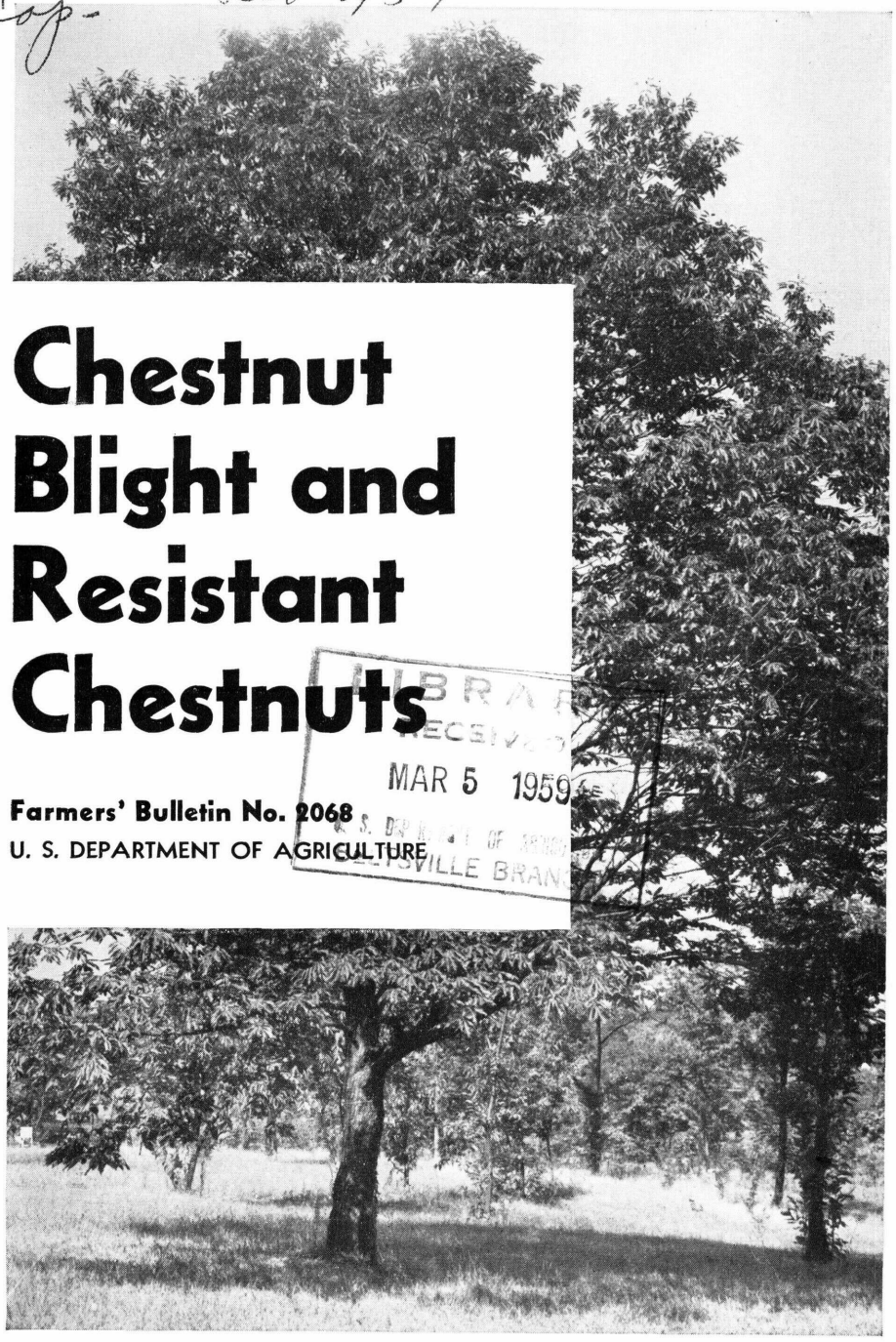

Chestnut Blight and Resistant Chestnuts

Farmers' Bulletin No. 2068
U. S. DEPARTMENT OF AGRICULTURE

The American chestnut has been almost entirely destroyed by chestnut blight. However, roots of dead chestnuts continue to sprout. Farmers are asking about these root sprouts and their apparent resistance to chestnut blight. They are also inquiring about a replacement for this valuable tree species. Answers to these questions are given in this bulletin.

Contents

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Chestnut Blight and Resistant Chestnuts

By the Tree Nut Section, Fruit and Nut Crops Research Branch, Crops Research Division, Agricultural Research Service [1]

THE CHESTNUT BLIGHT EPIDEMIC

Chestnut blight was first observed and recognized as a new disease in this country at the New York Zoological Park in 1904. Later a fungus [2] native to Japan, China, and Korea was proved to be the cause of this disease. Probably the blight fungus had entered this country on Asiatic chestnut nursery trees. Before 1912 we did not have a plant quarantine law. As is often the case with introduced pests, the blight fungus proved to be more virulent here than in the countries where it is native. The infection spread rapidly from its center at New York City. Soon it reached far into New England (fig. 1). Moving still more rapidly to the south, it advanced into the Allegheny Mountains and down through the Appalachians (figs. 1 and 2).

Birds, insects, and wind carried the blight fungus from infected trees to healthy ones, both nearby and far away. Shipments of infected nursery stock, seed, bark-covered poles, and rough lumber also carried it. New infection centers resulted, often many miles ahead of the main infected area. Advance spots rapidly enlarged and joined, forming continuous infected zones. Most of the early efforts at control by Pennsylvania and other States consisted in locating and cutting out advance infections. These efforts delayed the progress of the disease, but it soon became apparent that control was impracticable.

Less than 50 years after the blight fungus was discovered in this country, it had reached every part of the natural range of the American chestnut [2] (fig. 1). The chestnut killed is estimated to have been the equivalent of more than 9,000,000 acres of forest stands of pure chestnut. Isolated chestnut trees many miles from any other susceptible species were not safe from infection. Living old chestnut trees are now very rare.

Blight infections have been found in orchards and ornamental plantings of the American and European chestnuts in Washington, Oregon, California, and British Co-

[1] Partially in cooperation with the Connecticut Agricultural Experiment Station. New Haven, Conn., and the U. S. Forest Service.

[2] Scientific names of trees and fungi are listed on pages 20–21.

lumbia. A few new infections are still occurring but blight control apparently has been successful in all cases. Every tree found to be infected is destroyed. In Washington, Oregon, and California, State officials inspect chestnut plantings for the blight and take measures to control it; they also rigidly enforce an embargo on shipment of chestnut nursery stock from the East. Control of the blight in the Pacific States is favored by the absence there of any native growth of chestnut and by the fact that the chestnut plantings are isolated from each other. Any suspected infection in a western State should be reported to the State plant pathologist.

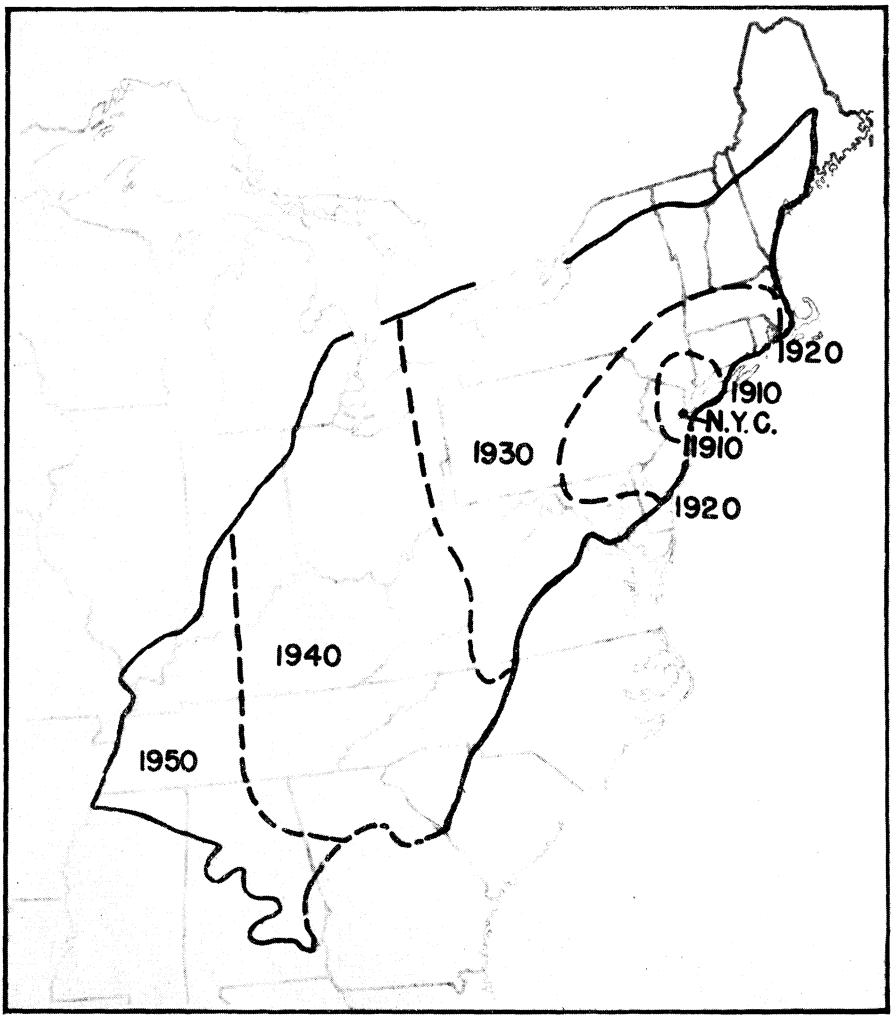

FIGURE 1.—Spread of the chestnut blight in the Eastern States. The solid line bounds the natural range of the American chestnut. Broken lines bound the areas within which the blight had killed at least half the American chestnuts at the dates indicated.

FIGURE 2.—Blight-killed American chestnut trees in the mountains of North Carolina.

SUSCEPTIBLE SPECIES

The chestnut blight fungus is most virulent on the American chestnut, but is only slightly less so on the European species.[3] It affects all the species of chinkapin native to the southeastern United States. Chinkapins range in size from small, low-growing shrubs to trees sometimes 2 feet or more in trunk diameter and 65 feet tall. Many chinkapins have been killed by the blight; however, chinkapins sprout from below ground level with such persistence and so frequently come up free of the blight that they may never be eliminated.

In greenhouse tests the blight fungus has killed the golden chinkapin, native to the Far West, and several Asiatic chinkapins.

The chestnut blight fungus grows and fruits on several species of oak in the United States; in many areas it seriously damages one of them—post oak, which has a standing volume of over 5 billion board-feet. Blighted post oaks have been found in various States from Connecticut to Florida and westward to Tennessee, always in areas where native chestnut had been blight killed. In post oak, open blight cankers, within which the wood is exposed, frequently result in death of treetops, but often the fungus grows in the outer bark only and does no

[3] The blight fungus is spreading rapidly in Italy and has entered Switzerland and Yugoslavia. The United States imports about 20,000,000 pounds of European chestnuts each year, chiefly from Italy. As the blight continues to spread, Europe will export fewer chestnuts.

damage. The fungus sometimes grows on dead chestnut oak, red maple, shagbark hickory, and staghorn sumac. In Europe, it has attacked three of the native oak species.

THE BLIGHT FUNGUS

The blight fungus grows mainly in the bark of chestnut trees, forming masses of flattened threadlike strands, called mycelia. Mycelial strands feed upon and kill the bark tissues. They advance through the bark much as plant roots advance through the soil, and form buff-colored mats or fans in the bark and cambium (fig. 3). The fungus continues to grow around chestnut trunks or limbs until it encircles them. The affected parts then die.

FIGURE 3.—Mycelial fans of the chestnut blight fungus, revealed by scraping away the outer bark from part of a cankered chestnut stem.

The fungus forms fruiting bodies, or blisters, in and on dying and dead bark. These blisters look like yellow, orange, or red-brown pinheads dotted over the surface of the cankers (fig. 4). They bear microscopic spores, which correspond to the seeds of higher plants. Spores of one type, called pycnidiospores, are produced within some of the blisters in great numbers. In damp weather they are forced out in slender sticky ribbons, much as paste is squeezed from a tube. They then form tiny yellowish or orange-colored hairlike tendrils, called spore horns (fig. 5). Spores of this type, being sticky, adhere to insects, birds, and other animals and thus may be carried for long distances. Rain washes them into wormholes and wounds in tree stems and branches, where new infections may develop.

Blisters producing spores of a second type, called ascospores, are made up of flask-shaped structures with very small openings. These spores do not form spore horns. They are borne within the flasks in groups of eight, each group enclosed in a thin, transparent sac. Under favorable conditions of moisture and temperature, the sacs push up through the neck of the flask and burst, throwing the spores into the air. Thus freed, the spores are carried by air currents, often for great distances.

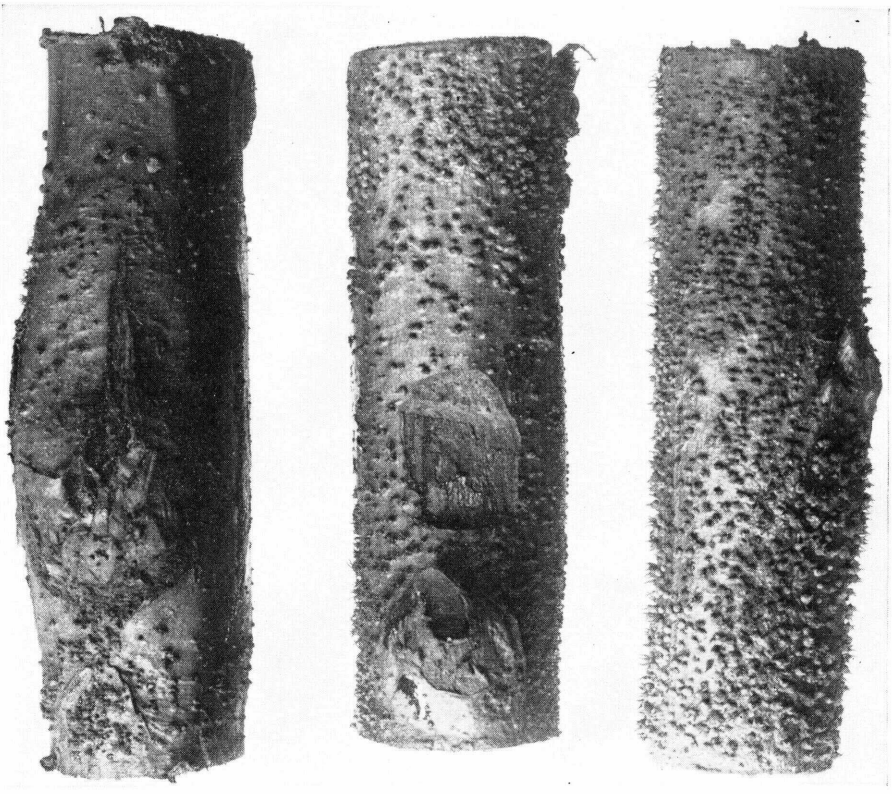

FIGURE 4.—Fruiting bodies (blisters) of the chestnut blight fungus.

SYMPTOMS OF THE DISEASE

Yellow or brown leaves on a blight-infected branch, in striking contrast with the normal green foliage, are usually the first noticed sign of the presence of chestnut blight. On a branch killed in early spring, the dead leaves are smaller than normal; on one killed later in the season, the dead leaves are full sized. The leaves and burs of a blighted branch usually remain attached during the winter. Dead chestnut branches with attached leaves do not, of course, always indicate chestnut blight. When the chestnut blight fungus is responsible for the dying, a canker can be found on the dead branch or the trunk, usually below the lowest killed leaves. Water sprouts, or suckers, frequently develop below the cankers and indicate canker location (fig. 6).

Yellowing, wilting, and stunting of leaves are symptoms of chestnut blight and also of Phytophthora root rot. This root rot is another fungus-caused disease that has been fatal to many native chestnuts and chinkapins in the South, especially at the lower elevations. Chestnut blight can be distinguished from Phytophthora root rot because blight-infected trees always have cankers and mycelial fans.

Young cankers on smooth-barked,

vigorously growing trees are easily recognized by their yellowish-brown to orange surface color, which contrasts sharply with the grayish-green color of normal bark (fig. 7). The cankered area may be sunken below the surrounding healthy bark, raised above it, or partly sunken and partly raised (fig. 8). After the fungus kills smooth bark through to the sapwood, a sunken canker is formed when the dead bark dries and becomes thinner than the living bark. Fruiting bodies of the fungus soon appear on the dead bark. Sometimes the infected bark of vigorous trees is not killed outright and new bark tissues grow, forming a swollen canker (fig. 8). Fruiting bodies of the fungus seldom appear on swollen cankers.

On thick-barked limbs and trunks a young blight infection causes very little change in the outward appearance of the bark. As the disease progresses, abnormal splits or cracks often appear in the thick bark, exposing some of the buff-colored infected inner bark, and fruiting bodies develop in bark splits or cracks.

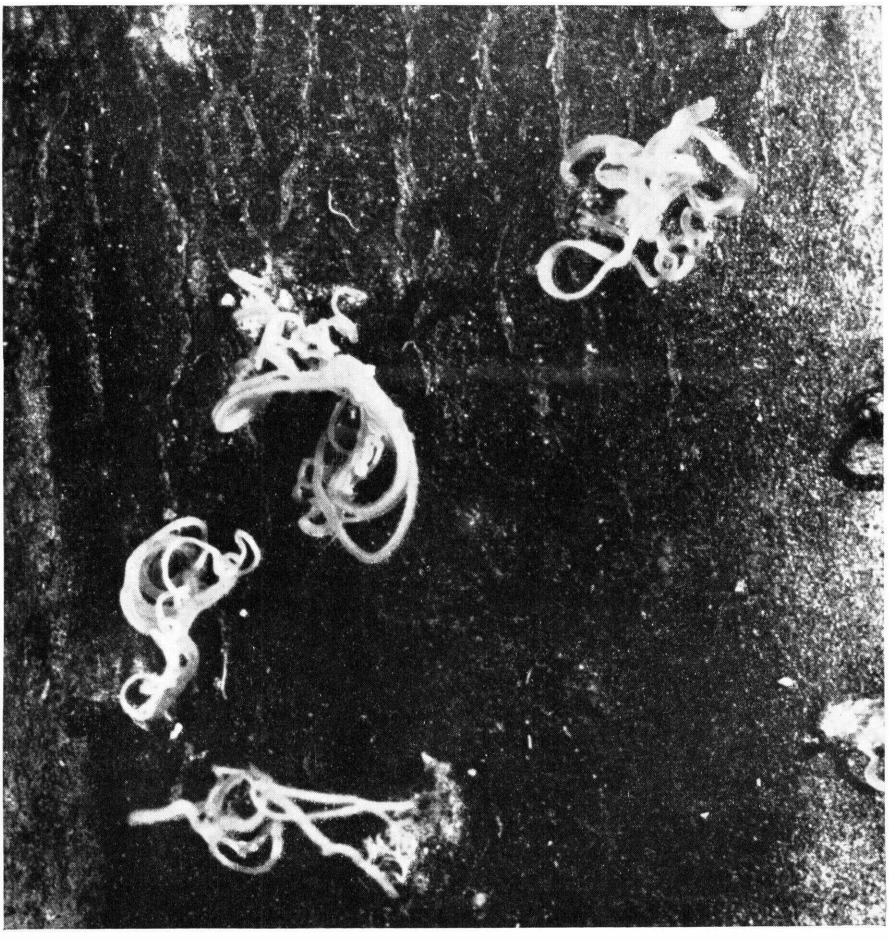

FIGURE 5.—Spore horns of the chestnut blight fungus. (About 6 times natural size.)

FIGURE 6.—A swollen blight canker, with suckers below it.

DETERIORATION AND USE OF BLIGHT-KILLED CHESTNUT

Before the blight fungus attacked, chestnut made up 25 percent of the forest stands on 33,000,000 acres in the southern Appalachians. The timber was used for tannin extraction, lumber, poles, ties, mine props, piling, fence posts, cordwood, and pulpwood. Sawed chestnut lumber was much in demand.

The bark of blight-killed American chestnut begins to loosen about a year after the killing. After 8

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years, about 90 percent of the bark has fallen off. Decay of sapwood accompanies the loosening of the bark, and as the sapwood sloughs off the heartwood begins to crack, or check. The heartwood of the American chestnut is so durable that blight-killed trees have frequently remained standing for 20 years or more.

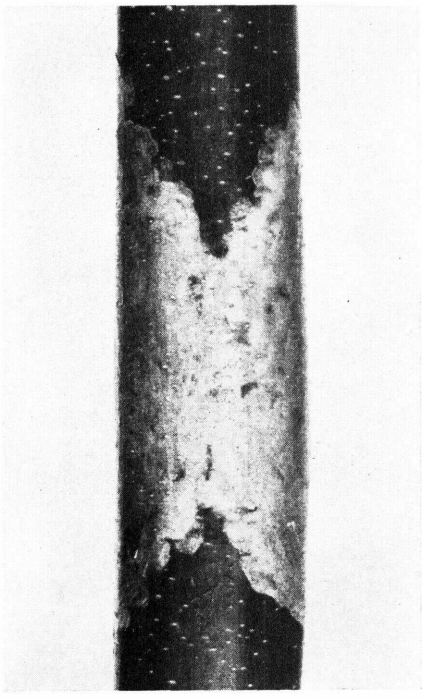

FIGURE 7.—Blight canker encircling a smooth-barked chestnut limb. The infection started on the opposite side and the canker advanced around the limb in both directions.

Utilization of blight-killed chestnut was studied by the United States Forest Service and by forestry departments of States within the blight area. It was found that after the first few years the dead chestnut timber deteriorated at a rate averaging about 4 percent per year. Tests made by the United States Forest Products Laboratory showed, however, that the heartwood of chestnut trees dead for 1 to 8 years was almost as sound as that of healthy trees. Loss of bark and sapwood and the presence of checks and wormholes in the heartwood do not prevent utilization of chestnut that has been dead for as long as 20 or 30 years.

Even today some companies offer chestnut lumber for sale, and extract plants continue to use long-dead chestnut wood as a source of tannin. In fact, this wood is still the source of most of our domestic production of vegetable tannin, a material needed in tanning leather. By 1961, however, practically all the operable chestnut will be gone from Georgia, Kentucky, and Tennessee and the volume remaining in North Carolina, Virginia, and West Virginia will be extremely scattered and inaccessible.

SEARCH FOR BLIGHT-RESISTANT AMERICAN CHESTNUTS

In 1918, when it became apparent that direct control of chestnut blight in the Eastern States was impracticable, a search began for American chestnut trees and sprouts resistant to the blight. Individual native chestnuts have been found to differ little in susceptibility to the blight. Very few large chestnut trees still survive in regions where blight has been present for a long time. Seedlings from these trees have been tested but have proved to be susceptible to the blight.

The American chestnut produces many sprouts from the roots, especially after blight killing. Its roots are more blight resistant than the parts above ground. Therefore, chestnut sprouts are now found throughout the natural range of the American chestnut. Both sprouts

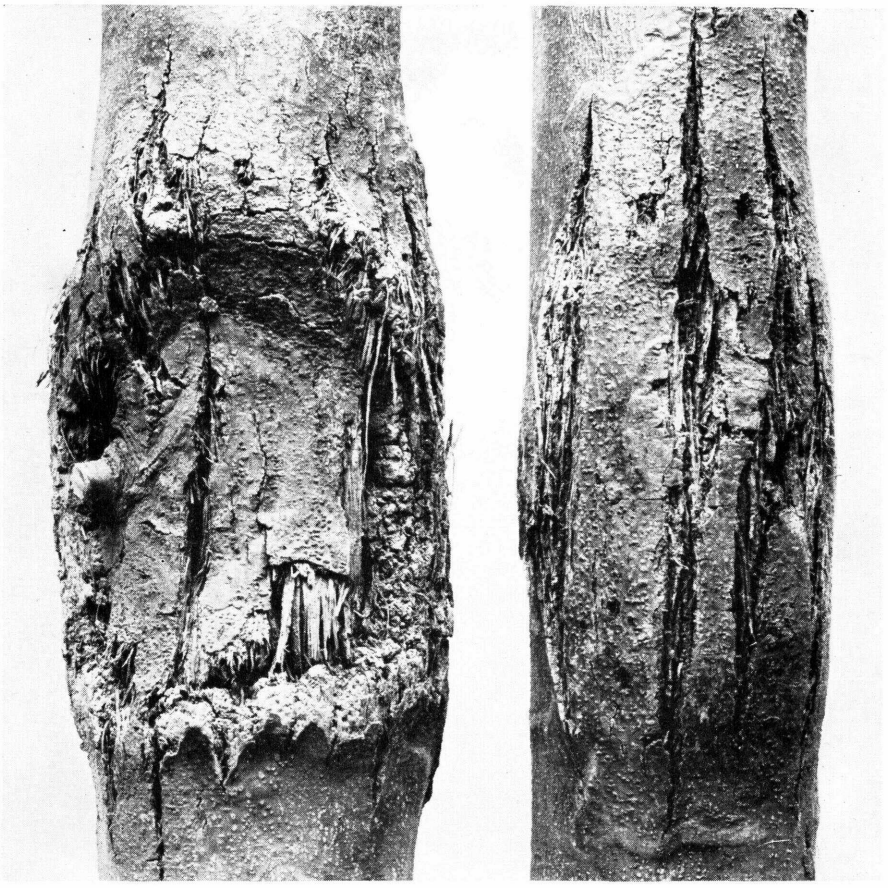

FIGURE 8.—The central part of the canker at the left is sunken where the fungus has killed the bark through to the sapwood. The canker at the right is slightly swollen and has the cracks characteristic of swollen cankers.

and seedling trees may escape the blight for a number of years, especially in localities where chestnut trees and blight infections are rare. Those that do so are not necessarily resistant and may eventually become infected with the blight and die as a result.

For a number of years after the chestnut trees in different localities were killed by the blight, the sprouts rarely reached a diameter of more than 2 inches before they in turn were killed. Now, in some of these localities some sprouts reach a diameter of 5 inches or more—a few of them even producing viable nuts—before they are killed by the blight. There are fewer blight fungus spores present to cause infection, because of the disappearance of many of the old blighted trees.

The United States Department of Agriculture and the Connecticut Agricultural Experiment Station are glad to receive reports of any large American chestnut trees that appear to be resistant after having

been exposed to the blight for 25 years or longer. Such reports should be addressed to the United States Agricultural Research Service, Fruit and Nut Crops Research Branch, Beltsville, Md., or the Connecticut Agricultural Experiment Station, New Haven, Conn.

BLIGHT-RESISTANT ASIATIC CHESTNUTS

Asiatic chestnut species, although not immune to the blight, are highly resistant to it. They are resistant to Phytophthora root rot, also. Therefore, many seeds and scions of Asiatic chestnut species have been brought into the United States. These have been tested to determine whether the Asiatic species are suitable for extensive planting in this country.

In Asia there are 3 principal species of chestnut and 1 of chinkapin: The Chinese chestnut, the Japanese chestnut, the Seguin chestnut, and the Henry chinkapin.

The Chinese chestnut is more resistant than any other chestnut species to the blight fungus. Its nuts (fig. 9, *A*) are sweeter and finer textured than those of the Japanese chestnut and usually are larger than those of the American chestnut (fig. 9, *B*). The Chinese chestnut is the hardiest of the Asiatic chestnuts. Its natural range, extending from south China, at elevations as great as 7,000 feet, north beyond Peiping, includes areas with very severe climate. In the northern part of its range the tree thrives only on the better sites, particularly lower mountain slopes where it has some protection, good air drainage, good soil, and the advantage of underground water from the slopes above.

Chinese chestnuts growing vigorously on good sites in the United States have seldom been injured by the blight. However, when trees of this species are in an unthrifty condition, owing to poor site, drought, or winter injury, they are sometimes severely attacked and may even be killed by the blight fungus.

Many selections of Chinese chestnut planted on favorable sites are growing well and producing good crops of nuts from southern New England to the Gulf States and from the Atlantic seaboard to just west of the Mississippi River. They have shown great differences in hardiness. In New York, for example, some of the trees have been damaged by a temperature of −20° F., but others have survived temperatures much lower than this without damage. The condition of the trees at the time of freezing, rather than the severity of the freezing temperature, is often the important factor. Trees that are cultivated or fertilized in the fall may harden off slowly and be severely damaged by sudden freezes. Unusually low temperatures in late winter or early spring may kill trees, especially young ones. Late spring frosts may kill Chinese chestnut buds, some of which may contain undeveloped flower parts, or kill back the young shoots for some distance. Trees with bark and cambium killed by low temperatures may leaf out in the spring and then die a month or so later. In the meantime the chestnut blight fungus may develop in the bark of such dying trees.

The Japanese chestnut grows wild in the mountains and hilly parts of Japan. The tree is not so tall as the American chestnut; the nuts range in size from that of the American to that of the European chestnut. Most Japanese selections have large nuts (fig. 9, *C*), but usually the kernels are coarse in texture and poor in flavor.

Reports from Asia and preliminary tests in this country indicate

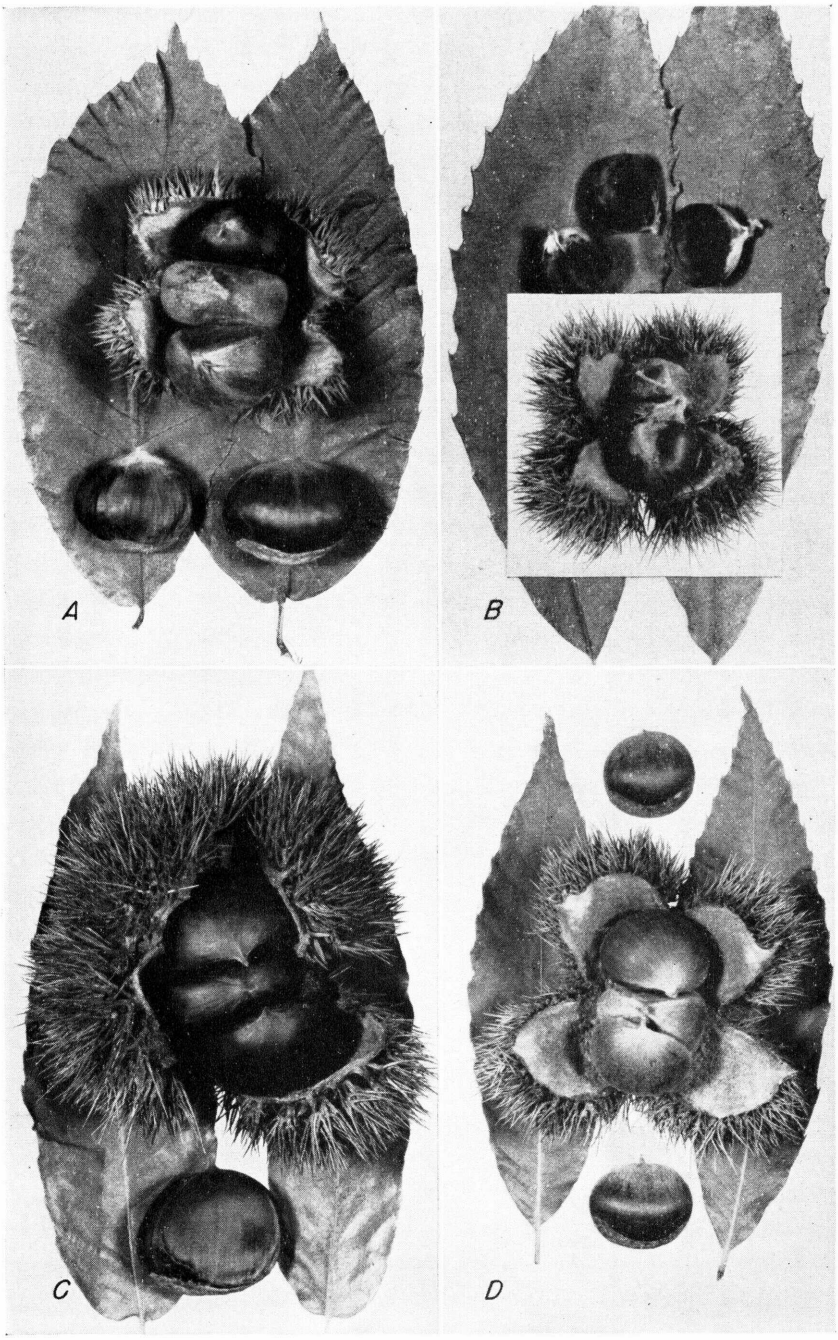

FIGURE 9.—Leaves, nuts, and bur of (*A*) the Chinese chestnut, (*B*) the American chestnut, (*C*) the Japanese chestnut, and (*D*) a first-generation hybrid between the Chinese and the American chestnut. (About half natural size.)

that the Chinese and the Japanese chestnut produce durable wood.

The Seguin chestnut usually does not attain a height greater than 25 or 30 feet. It grows in a rather warm climate in central and southern China. The nuts are very small but may have value as food for wildlife. A few trees of this species are growing well in the Southeast.

FIGURE 10.—Fifteen-year-old first-generation hybrids of Chinese and American chestnuts. They look like American chestnut trees and are just as vigorous, but they are more blight resistant.

Seguin chestnuts planted in other parts of the United States have not thrived.

The Henry chinkapin is a native of middle China, ranging from near the coast to the far west. In China it grows to a height of 75 or 90 feet and has a straight, symmetrical trunk. In this country the Henry chinkapin appears to be more susceptible than the Asiatic chestnut species to freezing temperatures and the blight fungus.

The blight resistance of chestnut species depends upon what type of tannin the bark contains and how soluble this tannin is. The tannins in the Chinese and the Japanese chestnut are more soluble than those in our native chestnut: it is for this reason that these two Asiatic species are the more blight resistant. The Chinese chestnut is more blight resistant than the Japanese because its tannin is more toxic to the blight fungus.

Owners of Chinese chestnut trees should make systematic observations on them, to locate the best ones for propagation as horticultural varieties or for use as parent trees for stock to be used in forest, wildlife, and ornamental plantings.

The United States Department of Agriculture has distributed more than half a million blight-resistant Asiatic chestnut trees, for testing, to foresters, soil conservationists, wildlife technicians, horticulturists, and private cooperators. **The Department of Agriculture does not now distribute blight-resistant chestnuts to the general public.** Such trees can be obtained from private nurseries and from some State forest and wildlife agencies.

BREEDING BLIGHT-RESISTANT CHESTNUTS

For many years the United States Department of Agriculture has been crossing the principal chestnut and chinkapin species on a large scale, in an effort to produce fast growing, blight-resistant hybrids to replace the American chestnut as a timber tree. In general, American chestnut trees that give evidence of having some blight resistance are crossed with Asiatic chestnut trees that have forest-tree form. Most of the first-generation hybrids from such crosses are vigorous and upright growing but too susceptible to the blight for practical use. Hybrids that show marked resistance to infection are used further in the breeding work.

One selection of Chinese chestnut, when crossed with American chestnut, produced fast growing, upright trees fairly resistant to the blight. A number of hybrids of this type were produced in 1932, and additional ones in 1935 and later. These first-generation hybrids resemble the American chestnut in such characteristics as rate of growth, form, and leaf shape (fig. 9, *D*). Their blight resistance is less than that of the Chinese parent but greater than that of the American. For the first 15 years, the progeny of the cross made in 1935 increased in height at a rate of almost 2½ feet per year, and in diameter at a rate of almost ½ inch per year (fig. 10). When these first-generation hybrids are backcrossed to the Chinese chestnut parent tree, the progeny is practically as resistant to the blight as the Chinese chestnut and has good forest-tree form. These first-generation hybrids are being backcrossed also to other selections of the Chinese chestnut in an effort to obtain better forest-tree form and a growth rate more like that of the American chestnut.

Special attention is being given to development of blight-resistant

chestnut and chinkapin hybrids suitable for wildlife plantings on some of the poorer soils and in various climates not well suited to the Chinese chestnut.

Chestnut breeding in Connecticut was begun in 1930 under the sponsorship of the Brooklyn Botanic Garden, with the cooperation of the United States Department of Agriculture. Since 1947 the Connecticut Agricultural Experiment Station has sponsored this work. At first, crosses of the American and Japanese species were made; in 1934 the American and the Chinese species were crossed; and in 1937 a Japanese × American hybrid was crossed with the Chinese chestnut. Among the progenies produced thus far, the Chinese × (Japanese × American) hybrids have the best forest-tree form and are the most blight resistant, with some Chinese × American hybrids a close second. They are being crossed with American chestnuts to obtain a better forest tree.

At the Connecticut Agricultural Experiment Station a method of grafting known as inarching has been practiced, to save for further breeding work those blighted hybrids having valuable characteristics such as erect habit and rapid growth.

BLIGHT-RESISTANT CHESTNUTS ON THE FARM

The Chinese chestnut has proved to be superior to the other Asiatic chestnuts for use on farms in the United States, because of its blight resistance and hardiness and the quality of the nuts. The Japanese chestnut should not be planted for nut production; its nuts are usually coarse in texture and poor in flavor.

Chinese chestnut seedlings are now offered for sale by a large number of nurseries. A partial list of these nurseries may be obtained from the Agricultural Research Service, United States Department of Agriculture, Washington 25, D. C. A few nurseries sell grafted varieties of Chinese chestnut. The grafted trees are more expensive than the seedlings. Some State forest and game agencies are growing and distributing Chinese chestnut seedlings. **The Department of Agriculture does not now distribute chestnut seedlings to the general public.**

Chestnut trees for planting in States west of the Great Plains should not be ordered from eastern nurseries. Quarantine laws of some of these States prohibit the filling of such orders, to prevent chestnut blight infection from being carried into new territory.

A chestnut tree is largely incapable of pollinating its own blossoms. To provide for cross-pollination and good crops of nuts, it is necessary to plant two or more seedling trees, or trees of two or more grafted varieties. For cross-pollination, trees should be planted not more than 60 feet apart.

Forest and Woodland Plantings

Efforts have been made to establish forest plantings of Chinese chestnut on abandoned rundown agricultural land and on grassy sites, but nearly all these have failed. The most successful plantings were made on sites having deep, fertile soil and good drainage. Cool sites with north or east exposures are best. The Chinese chestnut can endure shade for 1 or 2 years after planting, but it is not so tolerant of shade as shellbark and pignut hickory, white ash, sugar maple, or beech. To produce clear, straight stems, Chinese chestnuts must be

spaced not more than 10 x 10 feet apart and must have a good supply of moisture the year around. Successful plantings of Chinese chestnut have been made immediately after cutting of timber stands on sites on which yellow-poplar, northern red oak, and white ash grow well. On cut-over areas competing sprout and seedling growth of other tree species should be eliminated, preferably by poisoning, until the chestnut trees overtop surrounding growth. Chinese chestnut can well be planted on high-quality forest sites that have been poorly managed and as a result now support low-quality stands.

Good results have been obtained by girdling pole-size stands of yellow-poplar, northern red oak, white ash, and other species on high-quality sites and underplanting 1- or 2-year-old Chinese chestnut (fig. 11).[4] With this method of establishment, there is less competition from sprouts and seedlings of other species than if the trees had been clear cut. However, since this method sacrifices 15 or more years' growth of prime timber species it is not justified except where only a small planting of Chinese chestnut is desired for production of nuts as well as of other forest products.

Although farmland on which Chinese chestnut can be grown successfully is too valuable to be used extensively for this purpose, most farm woodlands can accommodate a block planting of 25 to 100 trees spaced about 10 x 10 feet. Such a planting (fig. 12) will provide decay-resistant posts and poles, nuts for wildlife and for human consumption, and a source from which chestnut can be seeded naturally in other parts of the woodland.

While the planted trees are becoming established, they need to be protected from various hazards. Where rabbits are numerous, a cylinder of woven wire should be placed around each young tree to keep rabbits from cutting off the stem. The wire should remain in place for at least 2 or 3 years after planting. Browsing and trampling by livestock or deer will cause the trees to become crooked, branchy, and dwarfed, and may eventually kill them. Fire is very destructive to chestnuts—although the Chinese chestnut, like the American, produces sprouts when the main stem is injured or destroyed.

Wildlife Plantings

Blight-resistant chestnuts could become an important source of food for wildlife in the Eastern States, because the nuts remain sound through the winter under a layer of fallen leaves. Before the blight epidemic, our native chestnut and chinkapins provided abundant food for squirrels, wild turkeys, bears, and deer.

Plantings such as those discussed under the heading "Forest and Woodland Plantings" provide food and shelter for wildlife. Other wildlife plantings may be made by similar methods in rough, hilly places where the soil quality and drainage are good, in fence corners, along fence rows and trails, and on the edges of forests and woodlands. It is usually necessary to cut out or poison competing vegetation each year until the chestnut trees are established.

Chestnuts planted in the pasture provide food for wildlife and shade and food for livestock. The young trees should be protected from live-

[4] DILLER, J. D. THE PLANTING AND CARE OF BLIGHT-RESISTANT CHESTNUTS FOR FOREST TREES. U. S. Bur. Plant Indus., Soils, and Agr. Engin., Forest Path. Spec. Release No. 15, 7 pp., illus. 1950. (Revised.)

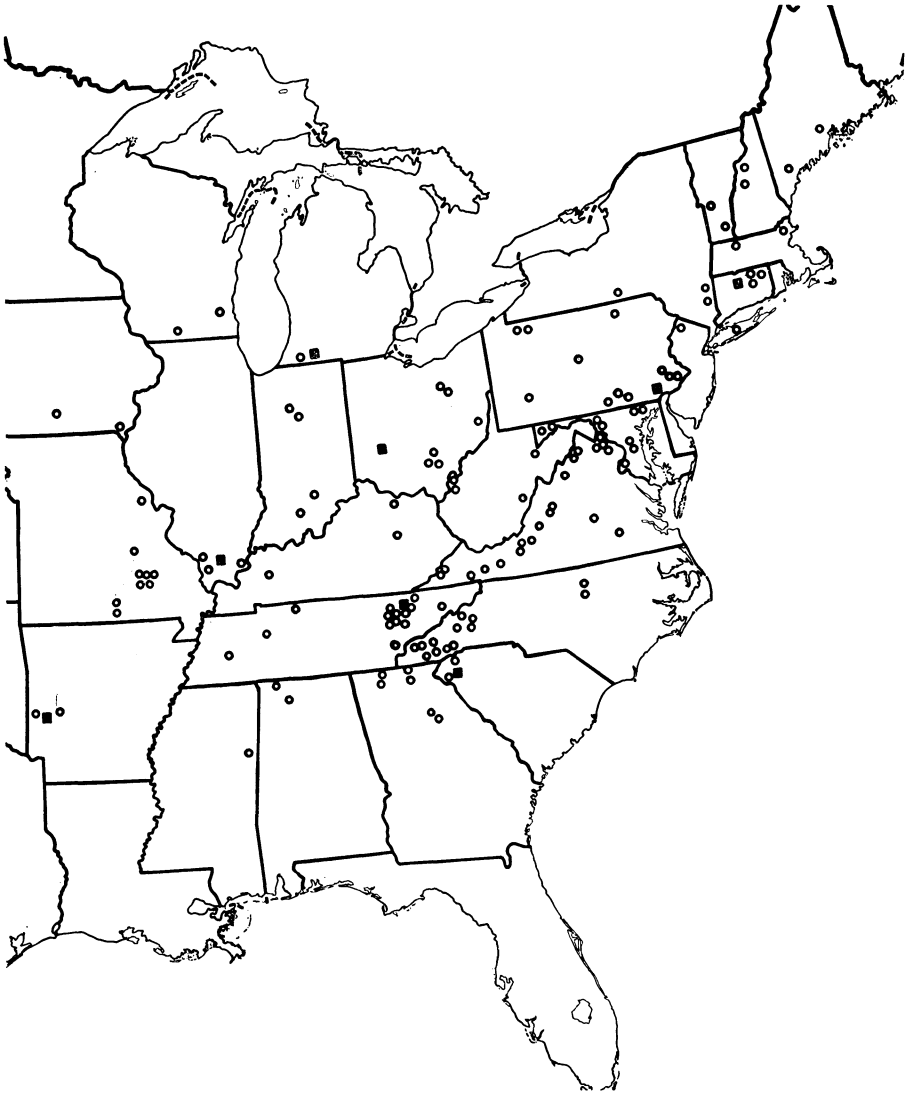

FIGURE 11.—Locations of quarter-acre demonstration plots of Chinese and hybrid chestnuts. (A circle signifies Chinese chestnut; a square, hybrid chestnut.) All the plots were established by girdling and underplanting. Usually the plots have required little maintenance.

stock with fencing until they become established. An area 6 feet in diameter around each young tree should be kept clear of grass and weeds for several years.

An important point to remember about wildlife plantings of chestnut is that only trees or parts of trees receiving full sunlight produce heavy yields of nuts.

Direct seeding is unsatisfactory as a method of planting blight-resistant chestnuts for wildlife purposes. Unprotected planted nuts

are eaten by squirrels, chipmunks, field mice, moles, and woodchucks. In tests, survival of planted chestnut seed was greatly increased by this method: Remove one end of a No. 2 tin can, cut a cross in the other end, turn out slightly the four corners at the center of the cross, then force the can into the ground over the planted seed. The can rusts away in 2 or 3 years and does not interfere with seedling development. Even with this method, however, direct seeding is less effective than planting 1- or 2-year-old seedlings.

Orchard Plantings

Orchards of Chinese chestnut can be grown on a wide variety of soils if the drainage is good. They do best on light, fertile sandy or gravelly loam that is well drained. The soil should be deep and the subsoil friable enough for the roots to penetrate to a depth of at least 4 feet. Heavy silt or clay soils should be avoided. Chestnut trees will not grow on low ground that is poorly drained. The soil should be moderately to slightly acid, although in a few instances well fertilized and well-cared-for trees are known to be making satisfactory growth on slightly alkaline soil. The trees will withstand some drought after they become well established, but they will not bear heavy nut crops without ample rainfall.

Orchard Chinese chestnuts should be planted on high, sloping ground having good air drainage, which tends to prevent damage from late spring frosts. The Chinese chestnut starts growing early in the spring, and is subject to frost injury. Trees located on low ground or in frost pockets are usually injured by late spring freezes. In some cases such freezes kill whole limbs or even entire trees.

The Chinese chestnut as an orchard tree seems to be well suited to conditions in the southeastern part of the United States. It has not yet been grown extensively enough in the North to demonstrate its suitability for large orchard

FIGURE 12.—A 16-year-old plantation of Chinese chestnut on the George Washington National Forest, Amherst County, Va. The planting was done after clear cutting of hardwood growth.

plantings there. It probably can be grown successfully in northern parts of the eastern United States if planted on appropriate sites. In general, orchard chestnuts are likely to grow well on areas and under conditions that are suitable for peaches.

There is a great deal of variation in the time required for seedling trees to come into bearing. Seedlings sometimes begin to bear nuts 4 to 5 years after the seeds are planted, but usually they require 7 or 8 years or more. Nut yield varies among trees grown from seed of different seedling trees and also among trees grown from seed of the same seedling tree. The nuts vary in size, shape, and color. Some trees mature crops early, others in midseason, and others late. Grafted trees sometimes bear nuts the second year after grafting. Recommended early bearing horticultural varieties of Chinese chestnut include the Kuling, Meiling, and Nanking, which the United States Department of Agriculture released to commercial nurserymen a few years ago. The Abundance variety, also, has done well in many plantings.

Management

On sloping land the trees should be planted on the contour, to prevent excessive erosion.

Chestnuts planted for nut production require maximum sunlight, since any tree or part of a tree not receiving full sunlight cannot bear a heavy yield of nuts. Spacing the trees 40 feet or farther apart permits them to develop into the spreading, rounded form needed for heavy nut production (fig. 13). Mature trees should be spaced at least 40 feet and preferably 50 or 60 feet apart.

Early spring planting is recommended. As a rule the trees should be planted when cold weather is no longer expected and as soon as the

FIGURE 13.—A 14-year-old Chinese chestnut orchard on the Eastern Shore of Maryland.

soil can be worked. Planting stock may be 1 to 3 years old. The trees should be planted at the same depth at which they grew in the nursery. In refilling the holes, it is important that the soil be worked in around the roots to avoid air pockets. Do not put any fertilizer in the tree hole.

Grass and weeds may kill transplanted chestnut trees before the trees are large enough to compete with them for soil moisture and minerals. Cultivate the trees often enough to keep grass and weeds from growing within 6 feet of any of them. Begin cultivation in early spring and continue into July or early August. Sow a winter cover crop in the fall if the entire orchard area is cultivated.

Row crops of various kinds, such as corn, cotton, and beans, can be grown in the orchard for the first few years.

On most soils Chinese chestnut trees respond to fertilizers. After the transplanted trees begin to grow, about 1 pound of 5–10–5 or 6–8–6 fertilizer should be applied around each tree and worked into the soil. The following year, at about the time growth starts, 2 pounds of the same fertilizer should be applied in the same way. Thereafter, the quantity of fertilizer applied per tree should be increased each year by about 2 pounds until it reaches 20 pounds.

Young orchard chestnut trees should be pruned to a single trunk. Chinese chestnuts tend to branch low on the trunk, and in many cases they develop a bushy form if not pruned. Such form makes it difficult to work around the trees and to harvest the nuts. Pruning sufficient to train the tree to the desired form is all that is required. Additional pruning reduces the size of the tree and delays nut production.

Harvesting and Storing Nuts

Nuts on Chinese chestnut trees usually begin to mature about the first of September in the Southern States and in late September or early October in the Northern States. At maturity, the burs usually open and release the nuts. Harvesting should begin as soon as the first nuts drop to the ground. Fallen nuts should be gathered at least every other day. Chestnuts are a perishable crop. If not properly harvested and stored, they decay or dry out quickly and become hard and bony.

Chestnuts may be kept for several months by storing them in metal cans at low temperatures with protection against drying out. The nuts remain in good condition if kept at a temperature of 32° F. and a relative humidity of about 70 percent. For ventilation each can should have several holes about $\frac{1}{16}$ inch in diameter. Small lots of nuts can be kept in the home refrigerator for several months if stored in cans or jars with loose fitting lids. When cold storage is not available the nuts may be stratified, that is, stored in layers alternating with layers of moist sand, or buried in the ground in a well drained location protected from rodents.

Insects[5] and Diseases

Two species of weevil often attack the nuts, causing them to become wormy. These weevils can be controlled by spraying the trees with DDT 3 times at weekly intervals. The best date to begin spraying varies from place to place and from season to season. In the vicinity of Washington, D. C., it is usually about August 15. To prepare the DDT spraying material,

[5] Insect control measures were prepared by Entomology Research Division.

add 4 pounds of a 50-percent DDT wettable powder to 100 gallons of water. For small quantities, add ⅔ ounce (approximately 16 level tablespoonfuls) of a 50-percent powder to 5 gallons of water. Mix the DDT powder thoroughly with the water. If harvested nuts are found to be infested with weevil eggs or larvae, these should be killed by immersing the nuts in water held at a constant temperature of 120° F. for 30 to 45 minutes, depending on the size of the nuts.

Japanese beetles feed on the flowers and leaves and often cause serious injury to the trees. These beetles can be controlled by spraying with a mixture of 2 pounds of a 50-percent DDT wettable powder to 100 gallons of water.

DDT is a poison and should be handled carefully in accordance with manufacturer's directions. Do not spray with DDT after the burrs begin to open.

Certain bacteria and fungi may attack the nuts, causing them to spoil or decay. Spoilage is more common in the Southeast than elsewhere, perhaps partly because of the higher temperatures and humidity that usually prevail there when the nuts are maturing. Nuts of the Kuling, Meiling, and Nanking varieties of the Chinese chestnut have good keeping qualities, and these varieties are recommended for orchard planting in the South, where nut decay is a serious problem.

Ornamentals

Blight-resistant chestnut trees make beautiful shade trees for the lawn or farmyard. They have attractive form and foliage. Most people enjoy the sight of a chestnut tree full of catkins in the spring and early summer or loaded with nuts in the fall. Chestnuts should not be planted where the branches would eventually overhang a roof from which water is collected for a cistern; the flowers and leaves have a disagreeable effect on the taste, odor, and color of water. A few trees, in full sunlight, will produce an abundant supply of nuts for family use, and, if properly stored, these can be enjoyed throughout the winter.

SCIENTIFIC NAMES OF TREES AND FUNGI MENTIONED

TREES

Common name	*Scientific name*
Chestnuts and chinkapins:	
American chestnut	*Castanea dentata*
Chinese chestnut	*Castanea mollissima*
European chestnut	*Castanea sativa*
Golden chinkapin	*Castanopsis chrysophylla*
Henry chinkapin	*Castanea henryi*
Japanese chestnut	*Castanea crenata*
Seguin chestnut	*Castanea seguinii*
Oaks:	
Chestnut oak	*Quercus prinus*
Northern red oak	*Quercus rubra*
Post oak	*Quercus stellata*
Other species:	
Beech	*Fagus grandifolia*
Pignut hickory	*Carya glabra*
Red maple	*Acer rubrum*
Shagbark hickory	*Carya ovata*
Shellbark hickory	*Carya laciniosa*
Staghorn sumac	*Rhus typhina*

TREES—Continued

Common name	*Scientific name*
Other species—Continued	
Sugar maple	*Acer saccharum*
White ash	*Fraxinus americana*
Yellow-poplar	*Liriodendron tulipifera*

FUNGI

Common name of disease	*Scientific name of causal fungus*
Chestnut blight	*Endothia parasitica*
Phytophthora root rot	*Phytophthora cinnamomi*

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CHECK up on these accident hazards around your farm . . .

√ Is farmyard clear of tools, broken glass, loose strands of barbed wire, nail-studded boards?

√ Are water tanks, cisterns, and wells protected?

√ Are ladders and steps in good repair?

√ Are pitchforks, rakes, shovels, and other sharp tools kept in racks?

√ Are electric circuits and appliances in good condition?

√ Is unused lumber carefully stacked?

√ Are buildings and fences in good repair?

clean up your farm

to make it attractive and SAFE